

The near-infrared spectrum of Mrk 1239: direct evidence of the dusty torus?

A. Rodríguez-Ardila^{1*} and X. Mazzalay²

¹*Laboratório Nacional de Astrofísica/MCT, Rua dos Estados Unidos 154, CEP 37500-000, Itajubá, MG, Brazil. E-mail: aardila@lna.br*

²*IATE, Observatorio Astronómico Córdoba, Laprida 854, X5000BGR, Córdoba, Argentina. E-mail: ximena@oac.uncor.edu*

ABSTRACT

We report 0.8–4.5 μm SpeX spectroscopy of the narrow-line Seyfert 1 galaxy Mrk 1239. The spectrum is outstanding because the nuclear continuum emission in the near-infrared is dominated by a strong bump of emission peaking at 2.2 μm , with a strength not reported before in an AGN. A comparison of the Mrk 1239 spectrum to that of Ark 564 allowed us to conclude that the continuum is strongly reddened by $E(B-V)=0.54$. The excess of emission, confirmed by aperture photometry and additional NIR spectroscopy, follows a simple blackbody curve at $T\sim 1200$ K. This suggest that we may be observing direct evidence of dust heated near to the sublimation temperature, likely produced by the putative torus of the unification model. Although other alternatives are also plausible, the lack of star formation, the strong polarization and low extinction derived for the emission lines support the scenario where the hot dust is located between the narrow line region and the broad line region.

Key words: galaxies:Seyfert – galaxies:individual:Mrk 1239 – galaxies:active – galaxies:nuclei

1 INTRODUCTION

Unified schemes of active galactic nuclei (AGN) invoke the presence of an obscuring dusty torus around the central engine, giving rise to type 1 objects for pole-on viewing and type 2 objects in edges-on sources. This obscuring structure would also absorb a significant fraction of the optical/UV/X-ray continuum of the central source and should radiate back this energy at IR wavelengths. In fact, dust reprocessing is regarded as the most likely source of the strong near- and mid-infrared (NIR and MIR, respectively) continuum emission in radio-quiet quasars and Seyfert galaxies. Observational evidence favoring models in which the IR continuum between 1 and 10 μm is predominantly or entirely dominated by emission from heated dust is abundant (Edelson & Malkan 1986; Barvainis 1987; Alonso-Herrero et al. 2003). Indeed, evidence of the presence of hot dust near the sublimation temperature in Seyfert 1 galaxies comes from the observation of a peak of emission with central wavelength between 2.2–3.5 μm found from JHKL and L' photometry (Glass 1992; Marco & Alloin 1998, 2000) in a few objects. Moreover, very recently, Rodríguez-Ardila et al. (2005) found in the inner 250 pc of Mrk 766, a narrow-line Seyfert 1 galaxy, this same excess of emission by means of NIR spectroscopy. They were able to determine accurately the form of

the NIR bump, confirming that it follows a simple blackbody function at $T=1200$ K. They found that the host dust emission accounted for up to 28% of the total NIR continuum flux in that object.

From above, the growing observational evidence of NIR thermal emission at temperatures close to the sublimation temperature of graphite grains in Seyfert 1 galaxies strongly supports the unified models for AGNs. Meanwhile, additional evidence is needed and many open questions have to be answered. In particular, it is necessary to investigate if the thermal emission could be related to a compact dust/molecular thick torus like the ones in the unified models of Pier & Krolik (1992) and Efstathiou & Rowan-Robinson (1995), for instance, or if it results from emission by hot dust ($T>900$ K) mixed with gas in the NLR/BLR interface region, shielded from the intense UV radiation field (Marco & Alloin 2000).

Here, we contribute to this discussion by presenting the most outstanding evidence of a NIR bump reported to date. It corresponds to the one displayed by Mrk 1239, a compact galaxy, classified as narrow-line Seyfert 1 (NLS1) by Osterbrock & Pogge (1985). Data collected over the past years point out that Mrk 1239 is indeed dusty. Goodrich (1989), for instance, reports that it is one of the three galaxies that display the largest percentage of polarization, both in the line and continuum, in the sample of 18 NLS1 he studied. Smith et al. (2004) modeled the polarization nature of this object and found that it was one of the rare cases of Seyfert 1 galaxies that appear to be dominated by scattering in an extended region along the poles of the torus. According to their results, the line-of-sight to the nucleus would pass through the relatively tenuous upper layers of the torus, extinguishing the continuum and BLR emission.

* Visiting Astronomer at the Infrared Telescope Facility, which is operated by the University of Hawaii under Cooperative Agreement no. NCC 5-538 with the National Aeronautics and Space Administration, Office of Space Science, Planetary Astronomy Program.

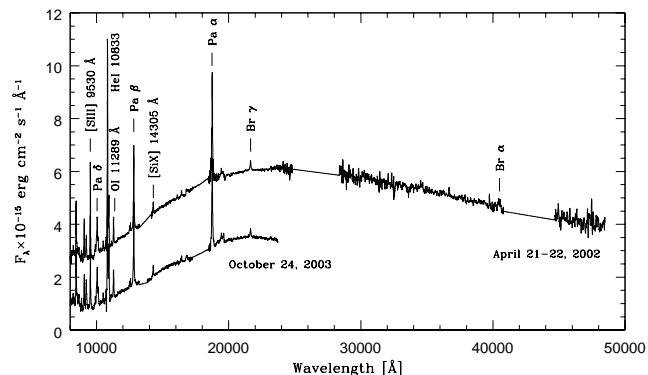


Figure 1. Observed NIR spectra of Mrk 1239 in the rest-frame of the galaxy. The spectrum taken on October 24 has been offset by 2×10^{-15} $\text{erg cm}^{-2} \text{s}^{-1} \text{\AA}^{-1}$ relative to that of April 21 for visualization purposes. The most important permitted and forbidden lines are marked. Note the strong excess of emission present in both spectra, starting at 10000 \AA , with peak at 22000 \AA .

This radiation, would be polarized further off by the dust located above or below the torus.

X-rays observations also confirm the dusty nature of Mrk 1239. XMM-Newton EPIC PN data suggest two light paths between the continuum source and the observer, one indirect scattered one, which is less absorbed, and a highly absorbed direct light path, in agreement to the wavelength-dependent degree of polarization in the optical/UV. Moreover, Mrk 1239 is classified as a 60 μm peaker (Heisler & De Robertis 1999) because of its “warm” far-infrared colours and spectral energy distribution peaking near 60 μm . They attributed these properties to dust-obscured active galactic nuclei (Keel et al. 1994; Hes et al. 1995), the obscuring material likely associated to the putative torus of the unified model.

This letter is organized as follows. In Section 2 we describe the observations, data reduction and resulting spectrum. Section 3 determines the internal reddening affecting the nuclear spectrum of Mrk 1239 and compares the observed NIR SED with that of Ark 564. It also analyzes the different components that contribute to the observed continuum. Section 4 examines the hot dust hypothesis for Mrk 1239 in the light of the strong thermal NIR excess of emission detected. Conclusions are in Section 5. Throughout this work we adopt a Hubble constant of $H_0 = 75 \text{ km s}^{-1} \text{ Mpc}^{-1}$.

2 OBSERVATIONS, DATA REDUCTION AND RESULTS

NIR spectra of Mrk 1239 in the intervals 0.8–2.4 μm and 2.0–4.9 μm (hereafter SXD and LXD, respectively) were obtained at the NASA 3 m Infrared Telescope Facility (IRTF) with the SpeX spectrograph (Rayner et al. 2003), atop Mauna Kea, on April 21, 2002 (UT) and October 24, 2003 (UT) for the SXD data and on April 22, 2002 (UT) for the LXD spectrum. The detector consisted of a 1024×1024 ALADDIN 3 InSb array with a spatial scale of $0.15''/\text{pixel}$. A $0.8'' \times 15''$ slit, oriented east-west, was used during the observations. The spectral resolution was 360 km s^{-1} at both setups. The total on-source exposure times amount to 1900 s and 1200 s for the April 21 and 22, 2002, and 1200 s for the SXD observation of October 24, 2003. The signal within the central $0.8'' \times 1''$ ($1'' = 380 \text{ pc}$) was summed up to obtain the nuclear spectrum. The light distribution of the galaxy was found to be cuspy, be-

ing dominated by the unresolved emission from the AGN. The data reduction, extraction and calibration procedures were done using the in-house software Spextool (Cushing et al. 2004) and Xtelcor (Vacca et al. 2003), provided by the IRTF Observatory. The spectra in the SXD and LXD settings, observed on consecutive nights, were merged to form a single 0.8–4.9 μm spectrum. The agreement in the continuum level in the overlapping region was excellent, with less than 5% of uncertainty. The SXD spectra obtained in October 2003 also agreed, within 10% of uncertainty, with the continuum level measured in the observation taken in 2002.

Figure 1 show the final NIR spectra of Mrk 1239 in the rest-frame of the object. In the regions where the atmospheric transmission drops to zero, a straight line was interpolated to connect the adjacent bands. It can be seen that the NIR spectrum is dominated by a strong bump of emission, peaking at 22000 \AA , also present in the October 24, 2003 observation. Also prominent in the spectra are emission lines of H I, He I and [S III]. No absorption lines that may indicate the presence of circumnuclear stellar population were detected. Since the main focus of this work is the continuum emission, the analysis of the line spectra is left for a future publication. To our knowledge, the only NIR spectroscopy available in the literature on this source is the *J* and *K* spectra of Heisler & De Robertis (1999). Because of the non-photometric conditions in which they were taken, there is a lack of continuity in the continuum level between the bands, preventing us to make any meaningful comparison. However, in Fig. 2g of Heisler & De Robertis (1999), the *J* continuum rises toward longer wavelengths. In the *K*-band, it continues rising up to 2.2 μm , where it seems to become flat, in accordance to our observations.

In addition to the NIR data, long-slit optical spectroscopy on Mrk 1239 was obtained on the nights of March 19 and 20, 2002, with the Cassegrain spectrograph attached to the 2.15 m telescope of the CASLEO Observatory, Argentina. The spectra cover the interval 3700–9600 \AA and were obtained with a $2''$ slit width and a 300 l/mm grating. The extraction and reduction process followed the standard IRAF procedure. As in the NIR region, the light profile distribution of the galaxy is dominated by the unresolved emission of the AGN. The aim of the optical data is to complement the NIR spectrum to map the optical-NIR continuum of this source. No significant variation (less than 5%) in the level of the continuum emission was detected in the overlapping region between the optical and NIR spectra (0.8–0.95 μm).

3 THE INTERNAL EXTINCTION IN MRK 1239 AND THE CONTINUUM EMISSION

In order to properly interpret the strong excess of NIR emission in Mrk 1239, it is first necessary to de-redden its optical-NIR continuum. To this purpose, we used as reference, the spectrum of the NLS1 galaxy Ark 564, whose continuum emission is well known and we assumed as typical of a NLS1 galaxy. Flux-calibrated FOS HST spectra in the optical region and SpeX IRTF spectra (Contini et al. 2003) were employed.

We started by dereddening the Ark 564 data by Galactic ($E(B-V)=0.03$) and internal extinction ($E(B-V)=0.14$), as determined by Crenshaw et al. (2002). The reddening law of Cardelli et al. (1989) with $R_V=3.1$ was used to this purpose. Then, assuming that the form and slope of the extinction-corrected optical continuum in Ark 564 represents the intrinsic continuum of Mrk 1239, we de-reddened the observed spectra of the latter object (already corrected by a Galactic $E(B-V)$ of 0.065) in small steep-

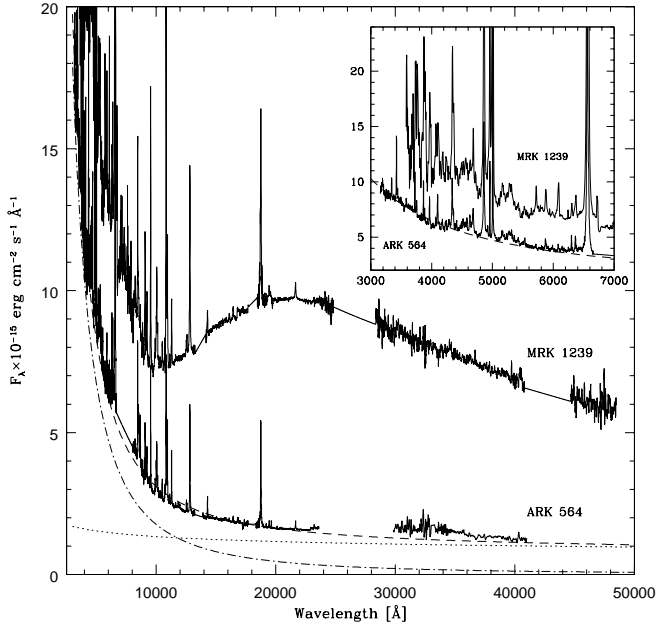


Figure 2. Comparison of the optical-NIR spectrum of Mrk 1239, after being dereddened by $E(B-V)=0.54$, with that of Ark 564. The box in the upper right corner shows a zoom in the optical region of both galaxies. The continuum emission of the latter object was modeled in terms of a sum of two power laws (dashed line): one that dominates the optical region (dot-dashed line) and another that dominates the NIR (dotted line). Note the lack of significant NIR excess of emission in Ark 564.

until the form of its optical continuum matches that of former. An $E(B-V)=0.54$ mag was necessary and was taken as the intrinsic reddening of Mrk 1239. This value is in excellent agreement to the one predicted by the polar scattering region scenario ($E(B-V) \geq 0.36$) proposed by Smith et al. (2004) if that mechanism becomes the dominant source of polarization. Note that had we used the NIR H I line ratios to determine the extinction, we would have obtained zero extinction. The measured $B\gamma$ flux is $2.76 \pm 0.20 \times 10^{-14}$ erg cm $^{-2}$ s $^{-1}$ while that of $Pa\beta$ is $1.91 \pm 0.1 \times 10^{-13}$ erg cm $^{-2}$ s $^{-1}$. Thus, the ratio $B\gamma/Pa\beta$ equals 0.14 ± 0.01 , somewhat lower than the intrinsic Case B value (0.17). This apparent inconsistency can be explained if NIR BLR hydrogen lines strongly deviates from Case B due to collisional and radiation transfer effects, as it the case for the optical lines.

Figure 2 shows the extinction corrected spectrum of Mrk 1239. It can be seen that after dereddening, the optical continuum of Mrk 1239 has the same steepness as that of Ark 564. Note the broad bump of emission starting at $\sim 1 \mu\text{m}$, with peak at 22000 Å. It dominates the NIR continuum distribution in Mrk 1239 but is absent in Ark 564.

Figure 2 also shows that at $\sim 1 \mu\text{m}$ there is a break in the steepness of the continuum. If the UV-optical continuum is well described by the a power-law of the form $F_\lambda \propto \lambda^\alpha$, the extrapolation of this function to the NIR region lacks of enough power to explain the NIR continuum emission. In Ark 564, for instance, where the strong bump of emission is not observed, an additional power law is necessary in order to reproduce the NIR SED. If we consider the continuum of Ark 564 as typical for a NLS1 galaxy, the break represents the end of the long wavelength side of the continuum attributed to the central engine and the onset of the thermal emission

from dust grains. The fact that Ark 564 displays a low percentage of polarization (Goodrich 1989) both in line and continuum, indicates that the dust content in the BLR of this object is small (also confirmed by the small value of intrinsic extinction). It means that in Ark 564 we are observing the true near-infrared shape of the big blue bump component, which up to date is essentially unknown (Kishimoto et al. 2005).

3.1 The components of the NIR continuum emission in Mrk 1239

The continuum emission displayed by Mrk 1239 in the interval 0.8–4.9 μm is complex and rather different from the one displayed by other NLS1 galaxies (see for example, the NIR spectra of other AGN presented by Rodríguez-Ardila et al. 2002). A comparison with the continuum of Ark 564 is, in fact, striking.

In order to characterize the NIR continuum emission in Mrk 1239, we used, as reference, the much simpler optical-NIR continuum of Ark 564. To this purpose, a composite function described by the sum of two power-laws of the form $F_\lambda \propto \lambda^\alpha$ was fitted to the data using the task *nfit1d* of the STSDAS package of IRAF. This composite function was chosen because it was clear that a single power-law cannot reproduce the optical-NIR continuum. Special care was taken to not include emission lines in the spectral windows used in the fit. The results are shown in Figure 2. The derived spectral indices are $\alpha_{\text{opt}} = -1.93$ and $\alpha_{\text{NIR}} = -0.2$ for the optical and NIR regions, respectively. From Figure 2, we see that this composite function cannot describe the continuum emission in the 1–4 μm region of Mrk 1239. The strong excess of emission that rises above the level predicted by the optical plus NIR power-laws indicates the necessity of an additional component.

An inspection to the overall shape of the bump suggests that it approaches that of a blackbody distribution. In order to test this hypothesis, we fitted a composite function—two power-laws, plus a Planck curve, to the observed optical-NIR SED. Additional constraints to the fit was imposed by adding photometric points for the L (3.5 μm) and N (10.5 μm) bands, taken from the literature (Spinoglio et al. 1995; Maiolino et al. 1995). In the fit, the power-law indices were constrained to the values found for Ark 564 (see above) while the temperature and amplitude of the blackbody function were left as free parameters. The results, displayed in Figure 3, show that a composite function, with a blackbody of temperature $T_{\text{bb}}=1210$ K, provides an excellent description to the the excess of emission over the power-laws. It should be noted here that the use of blackbody instead of a greybody is preferred because of the smaller number of free parameters that the former function requires. In the absence of observational constraints that justifies the use of a more complex function, they choice is for the one that offers an adequate solution with the minimum number of parameters to fit. See also Sect. 4

What is the origin of each of the three continuum components, all emitted in the inner 380 pc of the AGN? We associate the power-law that dominates the optical region to the long-wavelength side of the UV/optical continuum component, often called the big blue bump (BBB), thought to be emitted from an accretion disk around a supermassive black hole (Malkan 1983; Zheng et al. 1997; Constantin & Shields 2003). The NIR power-law is likely associated to the blue-end tail of the much broader infrared excess that dominates the IR SED of AGN, usually attributed to cold dust ($T \sim 40\text{--}80$ K), warmer than dust in normal spiral galaxies (Edelson & Malkan 1986), with peak emission at 60 μm , and observed in Mrk 1239 (Heisler & De Robertis 1999).

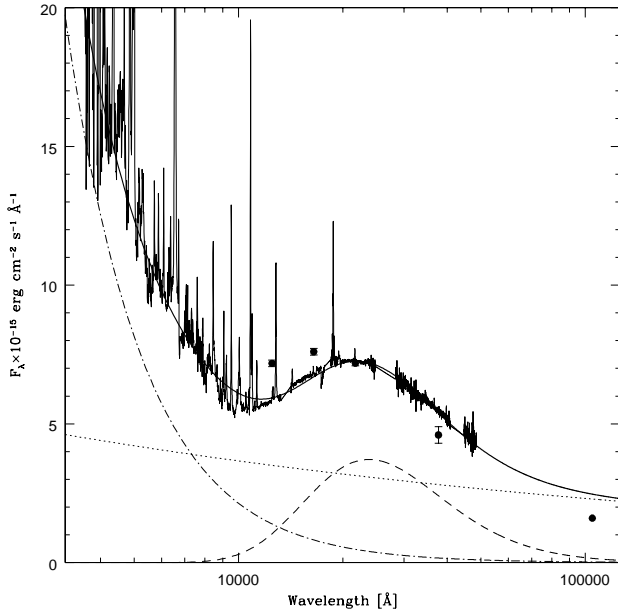


Figure 3. Intrinsic optical, NIR and MIR SED of Mrk 1239. The full circles are aperture photometry. In the JHK bands, they were taken from 2MASS. For the L and N region, they were taken from the literature (see text). The dotted-dashed and the dotted curves are the optical and NIR power-law functions, respectively, found for Ark 564. The dashed curve is the blackbody distribution of $T_{bb}=1210$ K that best reproduces the NIR bump. The thick line represent the sum of these three components.

The third component, well described by a Planck function of $T_{bb} \sim 1200$ K will be examined in the following section. Unfortunately, the lack of a spectroscopic survey of AGNs in the NIR prevents us to determine if that feature is common in Seyfert galaxies. The only reports to date of a similar feature comes from spectroscopy observations of I Zw 1 (Rudy et al. 2000), Mrk 478 (Rudy et al. 2001) and Mrk 766 (Rodríguez-Ardila et al. 2005), notably all NLS1 galaxies. In the former two objects, an excess of emission redwards of $1.3 \mu\text{m}$ over the underlying featureless continuum, is observed. The I Zw 1 and Mrk 478 data, however, are limited to $2.4 \mu\text{m}$. It is not possible to say what happens beyond that point. Note that the narrowness of this component turns it difficult to be detected in broad band photometry studies based on IRAS observations, for instance. Its presence, however, can be confirmed by means of 2MASS photometry. In Figure 3, we have plotted the JHK fluxes (full circles) reported for Mrk 1239, taken from NED. No photometry in the optical is available. Overall, the photometric points follow the NIR excess. The small overestimation of the photometric J and H flux over the spectroscopic one ($\sim 16\%$) can be due to line emission (H I and He I) and probably, underlying continuum emission from the host galaxy. Recall that the 2MASS data plotted is extracted from aperture photometry, of radius of $14''$, which may include contribution from the host-galaxy.

4 THE HOT DUST HYPOTHESIS

The adequate representation of the NIR bump by a blackbody distribution leads us to propose that it is due to emission from hot dust grains. The temperature derived from the fit, $T_{bb}=1200$ K, is close to the evaporation temperature of graphite grains, $T \sim 1500$ K,

Table 1. Masses of hot dust found in AGNs

Galaxy	Mass (M_{\odot})	Reference
Mrk 1239	2.7×10^{-2}	This work
NGC 7469	5.2×10^{-2}	Marco & Alloin 1998
Fairall 9	2.0×10^{-2}	Clavel et al. 1989
NGC 3783	2.5×10^{-3}	Glass 1992
Mrk 766	2.1×10^{-3}	Rodríguez-Ardila et al. 2005
NGC 1566	7.0×10^{-4}	Baribaud et al. 1992

and higher than the sublimation temperature of silicate grains ($T \sim 1000$ K; Granato & Danese 1994). Considering that our spatial resolution is limited to ~ 380 pc, it is very likely that dust at higher temperatures exists closer to the central source, ruling out the possibility of silicates as the main component of the nuclear dust grains.

Using the temperature of the blackbody as the average temperature of the graphite grains and a K band flux of 5.93×10^{-25} erg s $^{-1}$ cm $^{-2}$ Hz $^{-1}$ at $2.2 \mu\text{m}$ found for the blackbody component after subtracting the underlying composite power-laws, we can roughly estimate the dust mass associated with the bump. Following Barvainis (1987), the infrared spectral luminosity, in ergs s $^{-1}$ Hz $^{-1}$, of an individual graphite grain is $L_{\nu,ir}^{gr} = 4\pi a^2 \pi Q_{\nu} B_{\nu}(T_{gr})$, where a is the grain radius, $Q_{\nu} = q_{ir}\nu^{\gamma}$ is the absorption efficiency of the grains and $B_{\nu}(T_{gr})$ is the Planck function for a grain of temperature T_{gr} . Adopting, as in Barvainis (1987), a value of $a=0.05 \mu\text{m}$ for graphite grains and $Q_{\nu}=0.058$ and setting $T_{gr}=1220$ K, we find $L_{\nu,ir}^{gr}=9.29 \times 10^{-18}$ ergs s $^{-1}$ Hz $^{-1}$.

The total number of emitting grains (hot dust) can be approximated as $N_{HD} \approx L_{NIR}/L_{\nu,ir}^{gr}$.

Finally, for graphite grains, with density $\rho_g=2.26$ g cm $^{-3}$, $M_{HD} \approx 4.12 a^3 N_{HD} \rho_g$. Taking Mrk 1239 at a distance of 79.7 Mpc ($z=0.00199$, $H_0=75$ km s $^{-1}$ /Mpc), we obtained $N_{HD}=4.51 \times 10^{46}$ and $M_{HD}=2.7 \times 10^{-2} M_{\odot}$.

Table 1 compares the mass of hot dust derived for Mrk 1239 to that found in other AGNs. Our calculations show that Mrk 1239 harbors the second largest mass of hot dust reported to date in the literature for an AGN, only surpassed by NGC 7469. Note, however, that except for Mrk 766, all other previous measurements are based on photometric data, which do not take into account the underlying featureless continuum that we subtracted. Had we used the peak flux of the continuum, we would have obtained a value of $5.3 M_{\odot}$, ranking Mrk 1239 as the AGN with the largest content of hot dust found to date. The presence of dust near to sublimation temperature in Mrk 1239 has been largely predicted by dust emission models. In fact, the onset of the broad strong bump of emission at $1 \mu\text{m}$, with peak at $\sim 60 \mu\text{m}$, is set by the dust sublimation temperature of graphite grains at $T \sim 1500$ K. Why in Mrk 1239 exists such a large amount of hot dust, to the extent of creating a noticeable shoulder in the much broader IR SED attributed to warm dust, cannot be tell from our data. No doubt that Mrk 1239 is an excellent target to be studied spectroscopically with Spitzer in order to study the broad band IR emission of this object.

Regarding to the location of the hot dust, our aperture size implies that it must reside within the inner 380 pc from the centre. However, the high temperature of the dust imposes a tighter constraint to the location of its emitting region: the inner 100 pc. This value is deduced by inspecting Fig. 3 of Marco & Alloin (1998), where a plot of dust temperature as function of distance from the nucleus was constructed for NGC 7469. Note that we have as-

sumed that the dust in Mrk 1239 has similar properties to that of NGC 7469. Further support to this distance can be obtained following the results for NGC 1068 (Marco & Alloin 2000). These authors concluded that hot dust ($T_{\text{gr}}=1500$ K) should be extremely confined and located at a radius less than 4 pc. Although the precise location of the hot dust cannot be distinguished from our data, both scenarios are in accord to the polar scattering model of Smith et al. (2004). Likely, the combined effect of hot dust associated to the outer layers of the torus and the inner hot dust of the polar scattering cone contribute to enhance the bump observed in Mrk 1239. In fact, $10\ \mu\text{m}$ imaging of this object presented by Gorjian et al. (2004) shows clear evidence of bright extended emission in a cone-like structure, with the apex of the cone located at the nucleus. Although evidence of this extended emission is not seen in our data, we speculate that the hottest dust component should indeed contribute to the observed bump. No doubt, our results provides the first direct spectroscopic evidence of hot dust in AGN and show the potential that NIR spectroscopy has at unveiling that component.

If the strong NIR excess observed in Mrk 1239 is indeed thermal emission from very hot dust, one can ask why we only see emission at a single temperature if one would expect a range of temperatures? In that case, the NIR excess should resemble more closely to a sum of blackbody curves of decreasing temperatures. This question can be answered if we remember that the IR emission in Mrk 1239 is largely dominated by a much stronger bump, peaking at $60\ \mu\text{m}$ (see, for example, Figure 7 of Grupe et al. 2004, where the broadband continuum of this source is presented), indicating that a large interval of dust temperatures indeed dominates the bulk of the IR emission over the hot one.

5 FINAL REMARKS

In this letter we have reported the first discovery of an isolated NIR bump of emission in the NLS1 galaxy Mrk 1239. The continuum steeply rises toward longer wavelengths redward of $1\ \mu\text{m}$, peaking at $2.2\ \mu\text{m}$, where it starts to fall smoothly with wavelength. This excess of emission dominates the region between $1\text{--}5\ \mu\text{m}$. After comparing the optical continuum with that of Ark 564, we found that the continuum in Mrk 1239 is reddened by $E(B-V)=0.54$, appreciably larger for a type 1 object. This result agrees with polarimetry data, which points out towards a dusty polar scattering region. In order to adequately reproduce the NIR continuum, a Planck distribution of $T\sim 1200$ K is needed to account for the strong excess of emission over a featureless continuum of power-law form. We interpreted this component in terms of very hot dust, near its sublimation temperature, very likely located both in the upper layers of torus and close to the apex of the polar scattering region. If our hypothesis is correct, we have provided additional spectroscopic evidence of the presence of the putative torus of the unified model of AGNs.

ACKNOWLEDGMENTS

This research has been partly supported by the Brazilian agency CNPq (309054/03-6) to ARA and the European Commission's ALFA-II program through its funding of the Latin-American European Network for Astrophysics and Cosmology, LENAC to XM. This research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Labo-

ratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

REFERENCES

- Alonso-Herrero, A., Quillen, A. C., Rieke, G. H., Ivanov, V. D., Efstathiou, A., 2003, *AJ*, 126, 81
- Barvainis, R., 1987, *ApJ*, 320, 537
- Baribaud, T., Alloin, D., Glass, I., Pelat, D. 1992, *A&A*, 256, 375
- Cardelli, J.A., Clayton, G.C., Mathis, J.S. 1989, *ApJ*, 345, 245
- Clavel, J., Wamsteker, W., Glass, I. S., 1989, *ApJ*, 337, 236
- Constantin, A., Shields, J. C., 2003, *PASP*, 115, 592
- Contini, M., Rodríguez-Ardila, A., Viegas, S. M., 2003, *A&A*, 408, 101
- Crenshaw, D. M., Kraemer, S. B., Turner, T. J., Collier, S., Peterson, B. M., et al., 2002, *ApJ*, 566, 187
- Cushing, M. C., Vacca, W. D., Rayner, J. T. 2004, *PASP*, 116, 362
- Edelson, R. A., Malkan, M. A., 1986, *ApJ*, 308, 59
- Efstathiou, A., Rowan-Robinson, M., 1995, *MNRAS*, 273, 649
- Glass, I. 1992, *MNRAS*, 256, 23P
- Goodrich, R. W. 1989, *ApJ*, 342, 224
- Gordon, K. D., Witt, A. N., Rudy, R. J., Puetter, R. C., Lynch, D. K., et al., 2000, *ApJ*, 544, 859
- Gorjian, V., Werner, M. W., Jarret, T. H., Cole, D. M., Ressler, M. E., 2004, *ApJ*, 605, 156
- Granato, G. L., Danese, L. 1994, *MNRAS*, 268, 235
- Grupe, D., Mathur, S., Komossa, S., 2004, *AJ*, 127, 3161
- Heisler, C. A., De Robertis, M. M., 1999, *AJ*, 118, 2038
- Hes, R., Barthel, P. D., Hoekstra, H., 1995, *A&A*, 303, 8
- Keel, W. C., de Grijp, M. H. K., Miley, G. K., Zheng, W., 1994, *A&A*, 283, 791
- Kishimoto, M., Antonucci, R., Blaes, O., 2005, *MNRAS*, in press. astro-ph/0509341.
- Maiolino, R., Ruiz, M., Rieke, G. H., Keller, L. D., 1995, *ApJ*, 446, 561
- Malkan, M., 1983, *ApJ*, 268, 582
- Marco, O., Alloin, D. 2000, *A&A*, 465, 472
- Marco, O., Alloin, D. 1998, *A&A*, 336, 823
- Osterbrock, D.E., Pogge, R.W. 1985, *ApJ*, 297, 166
- Pier, E. A., Krolik, J. H., 1992a, *ApJ*, 401, 99
- Rayner, J.T., Toomey, D. W., Onaka, P. M., Denault, A. J., Stahlberger, W. E., et al. 2003, *PASP*, 155, 362
- Rodríguez-Ardila, A., Contini, M., Viegas, S. M., 2005, *MNRAS*, 357, 220
- Rodríguez-Ardila, A., Viegas, S.M., Pastoriza, M.G., Prato, L., 2002, *ApJ*, 565, 140
- Rudy, R. J., Mazuk, S., Puetter, R. C., Hamann, F. 2000, *ApJ*, 539, 166
- Rudy, R. J., Lynch, D. K., Mazuk, S., Venturini, C. C., Puetter, R. C., Hamann, F. 2001, *PASP*, 113, 916
- Schlegel, D. J., Finkbeiner, D. P., Davis, M. 1998, *ApJ*, 500, 525
- Smith, J. E., Robinson, A., Alexander, D. M., Young, S., Axon, D. J., et al., 2004, *MNRAS*, 350, 140
- Spinoglio, L., Malkan, M. A., Rush, B., Carrasco, L., Recillas-Cruz, E., 1995, *ApJ*, 453, 616
- Vacca, W. D., Cushing, M. C., Rayner, J. T. 2003, *PASP*, 115, 389
- Zheng, W., Kriss, G. A., Telfer, R. C., Grimes, J. P., Davidsen, A. F., 1997, *ApJ*, 475, 469